Asteroid Sampling and Trajectory Redirect Attempt (ASTRA)

Power Overview

AE 427

Spacecraft Preliminary Design

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The development of spacecraft capable of landing on an asteroid has opened new possibilities for scientific exploration and resource utilization in space. However, these missions pose unique challenges, particularly in terms of power supply. The purpose of power systems on spacecraft capable of landing on an asteroid is to provide the energy required to power the spacecraft's systems and instruments during the mission. These systems must be designed to withstand the harsh conditions of space and the challenges of landing on a small, irregularly shaped body. Additionally, the power systems must be efficient and reliable, as the success of the mission may depend on the availability of power for the duration of the mission. The unique requirements of these missions have led to the development of innovative power generation and storage technologies, such as solar arrays, radioisotope thermoelectric generators (RTGs), and batteries, among others. In this way, power systems play a critical role in enabling successful asteroid landing missions and advancing our understanding of the solar system.

The primary power generation source of ASTRA is two solar panels with an area of 8.5m^2 and a power output of 1,226 and 3,000 watts. However, this will depend on the distance from the sun and attitude configuration of the spacecraft. The spacecraft will consist of 30 Amp-hour Li-ion batteries, a 28-Volt bus, and a 28V pulsed power supply. The communications suit being utilized consists of Lockheed's Small Deep Space Transponder (SDST), a 50 W transmitter, and 15.8W Receiver. The different cameras require a stable power supply to capture high resolution images. The OCAMS consists of three camera units: PolyCam, MapCam, and SamCam. The OCAMS requires a power input of 5.3W and weighs approximately 0.6 kg per camera. The OVIRS is used to measure visible and Infrared light. This component will be used for measuring the composition and properties of the asteroid and requires 8.8W and weight 17.8kg. OTES will measure mineral and temperature properties and weigh 8.27kg and require 10.8W. REXIS is used to determine what elements are present and how abundant they are, which will determine the physical composition of 2008 DB. This component requires 12.4W and weighs 6.5kg. Finally, the OLA requires the most power of all included sensors to map the surface and allow the spacecraft to orient itself for landing. OLA's LIDAR scanner uses light to measure distance and has a power requirement of 59W and weighs 21.4kg.

ASTRA Proposed Power Budget				
Component	**Weight (kg)**	**Nominal Power Required (W)**	**Operating Voltage (V)**	**Maximum Current Draw (I)**
Power Generation & Storage				
Solar Array*	7.0	1226 - 3000	28	43.79 – 107.14
Battery	5.11	840	28	30
Ion Power Supply**	***	5000		
Instrumentation & Sensor Power Requirement				
Communications				
Transmitter	3.2	100	28	3.57
Receiver		31.6	28	1.13

Sensors				
OCAMS	1.8	15.9	28	0.57
OVIRS	17.8	8.8	28	0.31
OTES	6.27	10.8	28	0.39
REXIS	6.5	12.4	28	0.44
OLA	21.4	59	28	2.11
Actuators				
Nano Drill	1.05	15	28	0.54
Drill Arm	1.5	5	28	0.36
Landing Legs	6.63	5	28	0.18
Ultrasonic Drills x3	0.7	10	28	0.36
Propulsion				
Chemical Engines	***	200	28	7
Total Required		**473.5**	**28**	**16.91**
Total Generated		**2066-3840**	**28**	**73.79-137.14**
Redirection Thruster Power Requirement				
Ion Engine:	10	5000	***	***
Total Required:		**5000**	***	***
Total Generated:		**5000**	***	***
ESTIMATED TOTAL POWER REQUIREMENTS				
Weight (kg)	**Nominal Power Required (W)**	**Operating Voltage (V)**	**Maximum Current Draw (I)**	
88.96	**8840**	**28**	**137.14****	

Table 1: Displays ASTRA's power requirements.

*Solar Array: The power generated from the solar arrays depends on the spacecraft's attitude, position in orbit, and distance from the sun. Electrical components, such as resistors, will be installed to ensure a consistent voltage is delivered to the batteries when the solar panels are in use.

**The ion power supply will be utilized only for the ion engine.

***Operating voltage or current not specified by manufacturer.

Actuators

ASTRA will not have many different actuators, but the roles of these are critical to mission success. Most import of these actuators essential for mission success are the landing legs and attachment mechanism. ASTRA will be equipped with 3 landing legs which will be folded for launching purposes and deployed while enroute to 2008 DB. One leg will be unfolded at a time and locked into place. Speed is not critical for the deployment of these legs so only 5W of power will be

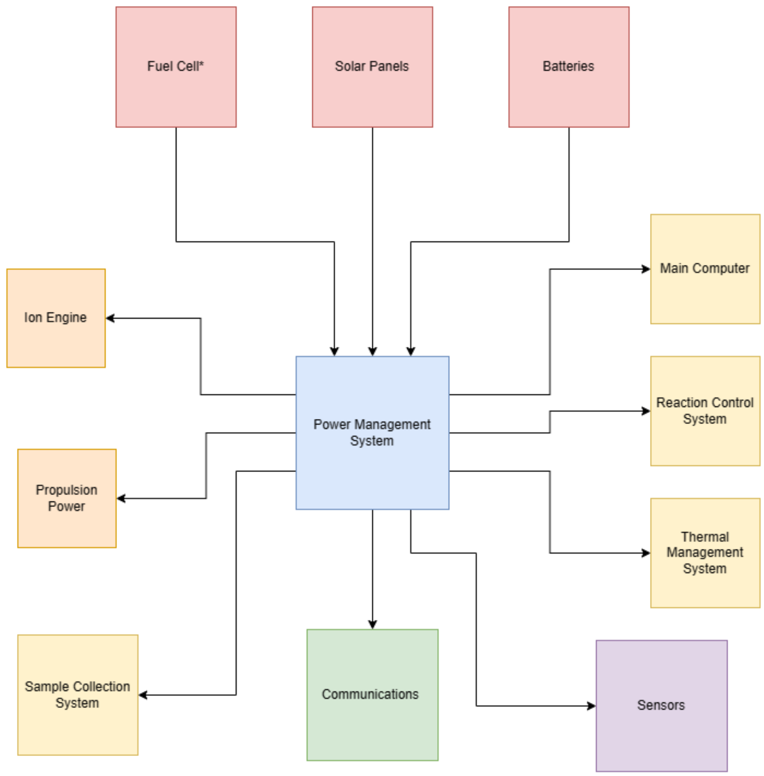

Figure 1. System power block diagram

needed. Each leg will weigh about 6.63 kg. Attached to each leg, an ultrasonic percussion drill will be used to secure ASTRA to 2008 DB. Each drill weighs about 0.7 kg and requires 10W of power. Each drill will be used at the same time to ensure a successful attachment totaling 30W. The entire landing leg mechanism will weigh about 21 kg.

Moving into the primary mission of ASTRA which is to determine the composition of 2008 DB, ASTRA will include a nano drill and arm like that of the Curiosity Rover. ASTRA's system will be shrunk down to a size for proportion to its mission rather than retaining the same 6-foot-long design the rover used. ASTRA will also have 2 less actuators on the arm because only one joint is needed for up/down and left/right motion. Actuators will be designed to move the arm, and the power requirements for these will be 5W to move the arm and nano drill assembly. The arm itself will weigh around 1.5 kg. The nano drill designed by Honeybee Robotics will be attached to the end of this arm. The power requirement for the drill is 15W. The nano drill weighs in at about 1.05 kg making the total weight of the arm, actuators and drill, 2.55 kg.

To have suitable power available for the redirection test, the spacecraft will turn off all non-essential components after the conclusion of data collection. The solar arrays will be extended on the surface of 2008 DB to recharge ASTRA's lithium battery. Solar panels will be stored before the final firing of the ion thrusters. The ion thrusters themselves will have an independent fuel and power cell to generate the necessary wattage.

ASTRA's ion thruster will be modified from the Ariane RIT 2X series which produces a power output in range of 4800-5300W. This system is beneficial in terms of preserving mass for almost

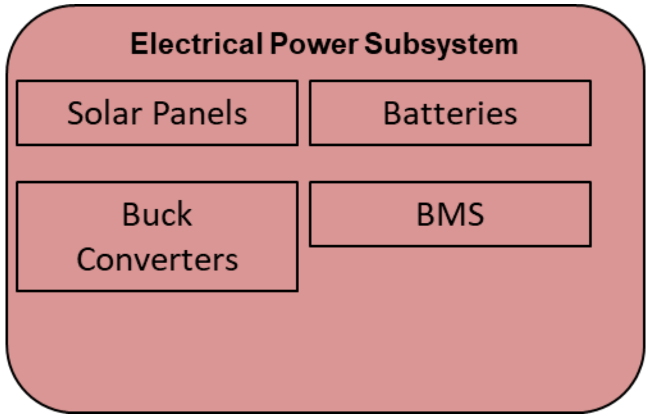

Figure 2. Power sub-system block diagram

all electrical satellites. The RIT 2X series is comprised of the largest Radiofrequency Ion thrusters that ArianeGroup produces. The Ariane RIT 2X series has the highest thrust efficiency and yields the best results for specific impulse over a certain period of time and utilizes electrical energy in a practical manner.

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